

IN THE CLAIMS:

1. (Original) A Pb-free solder consisting essentially of, in weight %, greater than about 90% Sn, about 3.6-3.8% Ag, about 0.6-0.7% Cu, and comprising an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the solder in an amount effective to form an intermetallic interface between the solder and a substrate, the intermetallic interface having a composite structure without scallop formation and including Sn islands.
2. (Original) The Pb-free solder of claim 1, wherein the additive element is Au and the composite structure comprises $(\text{AuCu})_6\text{Sn}_5$ grains and dispersed (βSn) islands.
3. (Original) The Pb-free solder of claim 2, wherein the substrate is a copper electrical component.
4. (Original) The Pb-free solder of claim 3, wherein the electrical component is a printed circuit board.
5. (Original) The Pb-free solder of claim 2, wherein concentration of the Au in the solder is greater than about 0.25 weight %.
6. (Original) The Pb-free solder of claim 5, wherein the concentration of Au in the solder is about 1 weight %.
7. (Original) The Pb-free solder of claim 5, wherein the concentration of Au in the solder is about 2 weight %.
8. (Original) A solder joint comprising a Pb-free alloy having a composition consisting essentially of, in weight %, greater than about 90% Sn, about 3.6-3.8% Ag, about 0.6- 0.7% Cu, and comprising an additive selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn,

Cr and combinations thereof, present in the Pb-free alloy in an amount effective to form an intermetallic interface between the alloy and a soldered component, the intermetallic interface having a composite structure free from scallop formation and including Sn islands.

9. (Original) The solder joint of claim 8, wherein the additive element is Au and the composite structure comprises $(\text{AuCu})_6\text{Sn}_5$ grains and dispersed (βSn) islands.

10. (Original) The solder joint of claim 9, wherein the soldered component is an electrical component having a copper substrate.

11. (Original) The solder joint of claim 10, wherein the electrical component is a printed circuit board.

12. (Original) The solder joint of claim 8, wherein concentration of the Au in the solder is greater than about 0.25 weight %.

13. (Original) The solder joint of claim 12, wherein the concentration of Au in the solder is about 1 weight %.

14. (Original) The solder joint of claim 12, wherein the concentration of Au in the solder is about 2 weight %.

15. (Original) A Pb-free solder consisting of, in weight %, greater than about 90% Sn, about 3.6- 3.8% Ag, about 0.6-0.7% Cu, and comprising an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the solder in an amount effective to form an intermetallic interface between the solder and a substrate, the intermetallic interface having a composite structure without scallop formation and including Sn islands.

16. (Original) A Pb-free solder joint consisting of, in weight %, about 90% Sn, about 3.6- 3.8% Ag, about 0.7% Cu, and comprising an additive selected from the group consisting of

Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the Pb-free alloy in an amount effective to form an intermetallic interface between the alloy and a soldered component to form a joint, the intermetallic interface having a composite structure free from scallop formation and including Sn islands.

17. (Withdrawn) A soldering process for a component comprising:

melting and solidifying a Pb-free solder consisting essentially of, in weight percent, about 90% Sn, about 3.6-3.8% Ag, about 0.6-0.7% Cu, and comprising an additive selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the Pb-free solder in an amount effective to form an intermetallic interface between the solder and a soldered component, the intermetallic interface having a composite structure free from scallop formation and including Sn islands.

18. (Withdrawn) The soldering process of claim 17, wherein molten solder is solidified in contact with an electrical component having a copper substrate to form a solder joint.

19. (Withdrawn) The soldering process of claim 18 wherein the additive is Au in an amount greater than about 0.25 weight %.

20. (Original) A modified Sn-Ag-Cu, lead-free solder alloy comprising an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the modified Sn-Ag-Cu, lead-free solder alloy in an amount effective to form an intermetallic interface between the alloy a substrate, the intermetallic interface having a composite structure without scallop formation and including Sn islands.

21. (Original) The modified Sn-Ag-Cu, lead free solder alloy of claim 20, wherein the additive element is Au and the composite structure comprises $(\text{AuCu})_6\text{Sn}_5$ grains and dispersed (βSn) islands.

22. (Original) The modified Sn-Ag-Cu lead free solder alloy of claim 21 wherein greater than about 0.25 weight % of the additive element is added to the alloy.

23. (Withdrawn) A method of making a lead-free alloy comprising:
melting and solidifying a Pb-free alloy consisting essentially of, in weight percent, greater than about 90% Sn, about 3.6-3.8% Ag, about 0.6-0.7% Cu, and comprising an additive selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the Pb-free alloy in an amount effective to form an intermetallic interface between the alloy and a substrate, the intermetallic interface having a composite structure free from scallop formation and including Sn islands.
24. (Withdrawn) The method of claim 23, wherein the additive element is Au and the composite structure comprises $(\text{AuCu})_6\text{Sn}_5$ grains and dispersed (βSn) islands.
25. (Withdrawn) The method of claim 24, wherein greater than about 0.25 weight % of the additive element is added to the alloy.
26. (Original) A modified Sn-Ag-Cu, lead-free solder alloy comprising an additive element of Au, the modified Sn-Ag-Cu, lead-free solder alloy having a quaternary eutectic reaction at $204.5 \pm 0.3^\circ\text{C}$, wherein the alloy comprises a eutectic microstructure with equilibrium phases of AuSn_4 , Ag_3Sn , (βSn) , and Cu_6Sn_5 .
27. (Original) The modified Sn-Ag-Cu, lead free-solder alloy of claim 26, having a composition comprising, in weight %, about 3.6-3.8Ag, about 0.6-0.7Cu, greater than about 0.9Sn.
28. (Withdrawn) A method of forming a composite interface layer between a copper substrate and a Sn-based lead free solder comprising the steps of:
providing a Sn-based lead free solder;
adding an additive element to the Sn-based lead free solder in an amount effective to form an intermetallic interface layer between the solder and the copper substrate, the intermetallic interface layer having a composite structure without scallop formation and

including Sn islands, wherein the additive element is selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof.

29. (Withdrawn) The method of claim 28, wherein the additive element is Au in an amount greater than about 0.25 weight %.

30. (Withdrawn) The method of claim 29, wherein the composite structure comprises $(\text{AuCu})_6\text{Sn}_5$ grains and dispersed (βSn) islands.

31. (Withdrawn) The method of claim 30, wherein the Sn-based lead free solder is provided in molten form.

32. (Withdrawn) The method of claim 28, wherein a coating layer is provided for the copper substrate.

33. (Withdrawn) The method of claim 28, wherein the Sn-based lead free solder is selected from the group consisting of Ag-Sn, Cu-Sn binary and ternary Ag-Cu-Sn alloys and Sn.

34. (Withdrawn) The method of claim 33, wherein the Cu-Sn binary alloy comprises, in weight %, greater than about 90% Sn and between about 0.1-5% Cu.

35. (Withdrawn) The method of claim 33, wherein the Ag-Sn binary alloy comprises, in weight %, greater than about 90% Sn and between about 0.25-7% Ag.

36. (Original) A composite, intermetallic layer on a Cu substrate, the composite, intermetallic layer having a composite structure without scallop formation and including Sn islands, wherein a molten solder comprises an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the solder in an amount effective to form the composite, intermetallic layer between the solder and the Cu substrate.

37. (Original) The solder of claim 1 comprising a base solder alloy of 3.8Ag-0.7Cu-Sn.
38. (Original) The solder of claim 5 comprising a base solder alloy of 3.8Ag-0.7Cu-Sn.
39. (Original) The solder of claim 1, wherein the Sn islands are about 0.2-0.8 μm .
40. (Original) The solder of claim 5, wherein the Sn islands are about 0.2-0.8 μm .
41. (Original) The solder of claim 1, wherein intermetallic size is about 0.3-1.2 μm .
42. (Original) The solder of claim 5, wherein intermetallic size is about 0.3-1.2 μm .
43. (Original) A Pb-free solder consisting essentially of, in weight %, greater than about 90% Sn, about 0.25-7% Ag, about 0.1-5% Cu, and comprising an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the solder in an amount effective to form an intermetallic interface between the solder and a substrate, the intermetallic interface having a composite structure without scallop formation and including Sn islands.
44. (Original) The solder of claim 43 comprising 4.7Ag-1.7Cu.
45. (Original) The solder of claim 44, wherein the additive element is Au.
46. (Original) The solder of claim 43 comprising 3.5Ag-0.9Cu.
47. (Original) The solder of claim 43 comprising 4.0Ag-0.5Cu.
48. (Original) The solder of claim 43 comprising 3.0Ag-0.5Cu.
49. (Original) A Pb-free solder consisting of, in weight %, greater than about 90% Sn, about 0.1-5% Cu an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn,

Cr and combinations thereof, present in the solder in an amount effective to form an intermetallic interface between the solder and a substrate, the intermetallic interface having a composite structure without scallop formation and including Sn islands.

50. (Original) A Pb-free solder consisting of, in weight %, greater than about 90% Sn, about 0.25-7% Ag and an additive element selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the solder in an amount effective to form an intermetallic interface between the solder and a substrate, the intermetallic interface having a composite structure without scallop formation and including Sn islands.

51. (Withdrawn) A soldering process for a component comprising:

melting and solidifying a Pb-free solder consisting essentially of, in weight percent, about 90% Sn, about 0.25-7Ag, about 0.1-5% Cu, and comprising an additive selected from the group consisting of Au, Ni, Pd, Fe, Co, Zn, Cr and combinations thereof, present in the Pb-free solder in an amount effective to form an intermetallic interface between the solder and a soldered component, the intermetallic interface having a composite structure free from scallop formation and including Sn islands.